a suspected paradoxical embolus to the intestines (overall mortality 11%). The eight surviving patients were discharged to home within 48 hours of the intervention and had normal PA pressures without any evidence of right heart strain on echocardiogram performed one month after their CDTT procedure.

Conclusions: Massive or submassive PE can be treated safely with CDTT in a community hospital setting. This can reduce the need for lengthy ICU stays, shorten overall hospital length of stay, eliminate the need for home oxygen therapy, and restore right heart function with an acceptable mortality rate. Development of institutional CDTT expertise in conjunction with protocols to administer this therapy early in the course of massive and submassive PE may yield significant mortality and morbidity benefits in community hospitals.

Treatment of Congenital Vascular Malformations Using a Multidisciplinary Approach: Results of a Prospective Study

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Background: Vascular malformations (VM) are a rare and complex group of lesions which may present serious pitfalls in diagnosis and management. We sought to evaluate the safety and efficacy of our previously described imaging protocol and therapeutic algorithm in the treatment of low flow and high flow vascular malformations in a large series of patients.

Methods: A prospective database of all patients treated by the multidisciplinary vascular malformation team at our institution between 2006 and 2011 was reviewed. Management decisions were based on patients' clinical profile as well as critical lesion characteristics, and included conservative care, sclerotherapy, embolization, surgical resection, or a combination of these modalities (Fig). Treatment goals were established by the patient and physician at the time of initial evaluation. An outcomes grading system based on patient and physician derived treatment goals, and assessment of response to management was applied (1=worse; 2=unchanged, 3=significantly improved, 4=completely resolved), and post-procedural complications were identified.

Results: The 136 vascular malformations in 135 patients included 59 (43.7%) males and 76 (56.3%) females, ranging in age from under 1 year to 68 years (mean = 25.3 ± 17.0). In order to facilitate application of the therapeutic algorithm, all patients underwent dceMRI to determine critical lesion characteristics including flow quality and lesion extension. Of the 105 (77.2%) low flow vascular malformations (LFVM), 23 (21.9%) were managed conservatively, 38 (36.2%) were treated with sclerotherapy (sodium tetradecyl sulfate, polidocanol, and/or ethanol), 18 (17.1%) were surgically resected, and 8 (7.6%) were managed with a combination of modalities. Of the 31 (22.8%) high flow vascular malformations (HFVM), 8 (25.8%) were managed conservatively, 8 (25.8%) were treated with transcatheter arterial embolization, 6 (19.4%) required embolization followed by sclerotherapy, and 5 (16.1%) were resected. Patients in all groups managed conservatively had minimal alteration in status. Response to sclerotherapy in the LFVM group resulted in improvement in 32 (84.2%) patients, surgical resection resulted in improvement in 16 (88.9%) patients, and combination therapy resulted in improvement in 8 (100%) patients. Treatment with embolization in the HFVM group resulted in improvement in 7 (87.5%) patients, while combination therapy resulted in improvement in 6 (100.0%), and surgical resection led to improvement in 4 (80%) [Table]. Complications were observed in 6 (6.8%) patients treated for LFVMs (0 with sodium tetradecyl sulfate or polidocanol, 4 with ethanol, 2 with resection), and 2 (7.4%) patients treated for HFVMs with embolization or combination therapy.

Conclusion: In this large cohort of vascular malformation patients, implementation of the proposed diagnostic and therapeutic algorithms in a multidisciplinary setting resulted in favorable outcomes with an acceptable complication rate in this challenging patient population.

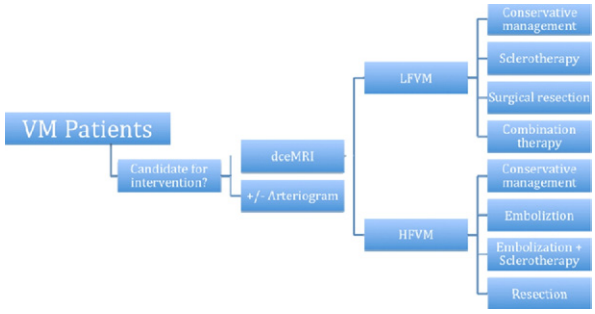

Fig.

Table.

Type N (%)	*Treatment*	*Treated N (%)*	*Outcomes N (%)*				*Complications N (%)*	*Specific complications*
			Worse	*No change*	*Significantly improved*	*Completely resolved*		
LFVM 105 (77.2%)	Conservative management	23 (21.9%)	2 (8.7%)	18 (78.2%)	2 (8.7%)	1 (4.3%)	0 (0%)	
	Foam sclerotherapy	31 (29.5%)	0 (0%)	2 (6.5%)	21 (67.7%)	8 (25.8%)	0 (0%)	
	Ethanol sclerotherapy	7 (6.7%)	0 (0%)	4 (57.1%)	3 (42.9%)	0 (0%)	4 (57.1%)	DVT, ulceration, bradycardia/ oxygen desaturation
	Resection	18 (17.1%)	0 (0%)	2 (11.1%)	3 (16.7%)	13 (72.2%)	2 (11.1%)	PE, Infection
	Combination therapy	8 (7.6%)	0 (0%)	0 (0%)	7 (87.5%)	1 (12.5%)	0 (0%)	
HFVM 31 (22.8%)	Conservative management	8 (25.8%)	0 (0%)	6 (75.0%)	1 (12.5%)	1 (12.5%)	0 (0%)	
	Embolization	8 (25.8%)	1 (12.5%)	0 (0%)	6 (75.0%)	1 (12.5%)	1 (12.5%)	Hemorrhage
	Embolization + sclerotherapy	6 (19.4%)	0 (0%)	0 (0%)	5 (83.3%)	1 (16.7%)	1 (16.7%)	Ulceration
	Resection	5 (16.1%)	0 (0%)	1 (20%)	1 (20%)	3 (60%)	0 (0%)	

Tabular data do not include 18 pts lost to follow up (4 HFVM, 14 LFVM), 2 pts treated with laser, and 1 pt who died prior to initiation of treatment.

Contemporary Outcomes of Vertebral Artery Injury: A Ten-Year Single-Center Experience

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Background: Vertebral artery injury (VAI) associated with cervical trauma is being increasingly recognized with more aggressive screening. Disparate results from previous literature have led to uncertainty of the significance, natural history and optimal therapy for VAI.

Methods: We performed a retrospective, single-center review from a level I trauma center for the previous 10 years of all VAI. Injuries were identified from search of administrative trauma database, a resident-run working database, and all radiology dictations for the same period. VAI were classified according to segmental involvement, Denver grading scale, and laterality. Analysis of associated injuries, demographics, neurologic outcome, mortality, length of stay, treatment plan, and follow-up imaging was also performed.

Results: Fifty-one patients with VAI were identified from 2001-2011 from a total 36,942 trauma admissions (0.13% incidence). Associated injuries were significant with an average NISS 29.6. Penetrating trauma occurred in 14%. Cervical spine fracture was present in 88% with VAI. Diagnosis was obtained with CT angiography in 95%. Screening was prompted by injury pattern or high-risk mechanism in all cases. Injuries classified accord-

ing to the Denver grading scale were; grades 1=24%, 2=35%, 3=4%, 4=35%, and 5=2%. Distribution across segments included; V1=18%, V2=67%, V3=31%, and V4=6%. Only one posterior circulation stroke was attributable to VAI. Overall mortality was 8% being associated with other injuries. Treatment rendered was antiplatelet therapy (50%), observation (29%), warfarin (17%) or stent (4%). Follow-up was obtained with 13% (n = 6) of survivors. CT angiogram or MRA demonstrated injury stability in 4 patients and resolution in 2 patients. Accuracy of the administrative trauma database was 53% compared with 96% for the resident-run working database.

Conclusions: Neurologic sequelae attributable to VAI was rare. Grade of VAI or vertebral artery segment did not correlate with morbidity. Posterior circulation stroke was low. Patient morbidity and mortality was attributable to severe associated injuries. Of those seen at follow-up, injury resolution or stability was documented by CT angiogram. A conservative approach with either observation or anti-thrombotic therapy is suggested. Our search strategy urges awareness of the limitations of administrative databases for retrospective vascular study.

Carotid Endarterectomy is More Cost-Effective Than Carotid Artery Stenting

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Background: In a clinical environment where there may be emerging clinical equipoise between two therapies, the cost of delivering that intervention becomes increasingly important. Carotid Endarterectomy (CEA) and carotid artery stenting (CAS) have both demonstrated a reduction in long-term stroke risk after successful intervention. While the CREST trial demonstrated no significant differences between CAS and CEA regarding the peri-operative risk when the primary endpoint of CVA, death or MI was examined, a meta-analysis of European randomized prospective trials in symptomatic patients strongly favored CEA as the safer procedure. In the United States, the percentage of gross domestic product (GDP) devoted to medical care continues to rise at a rate that is unsustainable. Going forward, more efficient use of health care dollars will be essential. Preferential use of the most cost-effective therapy for a given clinical problem should be part of the solution. In an effort to further compare treatment of carotid disease, we analyzed hospital cost and clinical outcome data of patients undergoing CEA and CAS.

Methods: A retrospective analysis of hospital cost and 30-day outcomes was performed on patients undergoing CEA and CAS between 1/1/2008 and 9/30/2010 at a single tertiary referral institution. The hospital patient database was queried using CPT codes to search for those patients who had either undergone CEA (CPT 35301) or CAS with embolic protection (CPT 37215) during the specified period.

Clinical Definitions: Patients were considered to be symptomatic from their carotid disease if they had experienced ipsilateral amarousis fugax, transient ischemic attack (TIA) or stroke. Urgent interventions were defined as those patients admitted with an acute cerebral or ocular ischemic episode who were found to have significant ipsilateral carotid disease and underwent intervention during the index hospitalization. The 30-day clinical major adverse event was defined as a composite of any stroke, death and MI.

Cost Calculation: The institution's financial department performed an analysis of hospital cost (not charges) on the main patient cohorts and subgroups detailed above. Professional fees were not included in this analysis. The cost of the procedure was based on a cost accounting method using the relative value unit (RVU) system. Each procedure or item charged to a case was assigned an RVU. Costs were then calculated based on the relative RVU valuation. The cost items were assigned to the following cost centers: labor expense, supply expense, facility/equipment expense, and miscellaneous. Once the total expense for the index hospitalization was calculated, it was normalized to 2010 costs based on the medical consumer price index. Statistical analysis was performed with Wilcox's analysis, X2, and Fisher's exact test.

Results: Three hundred and fifteen patients underwent either CEA (n = 174) or CAS (n = 141) between 1/1/2008 and 9/30/2010. Nine patients were excluded from the primary cohort (all receiving CAS) because they had other associated procedures during the index hospitalization which would have biased the economic analysis. Thus, the final examined cohort was 306 patients who underwent CEA (n = 174) or CAS (n = 132).

Demographics: There was a strong trend towards more symptomatic patients in the CEA cohort (44%, n = 78) compared to the CAS group (34% n = 45) which did not attain statistical significance (P = .058). The frequency of urgent intervention was similar between groups [CEA 12.6% (n = 22) vs CAS 10.0% (n = 14); P = .72). The mean age in the CEA and CAS groups was 70.1 ± 9.8 yrs. and 72.0 ± 9.7 yrs, respectively (P = .36). There was a trend towards a higher prevalence of medical co-morbidities in the CAS cohort compared to the CEA cohort (94.5% vs 88.9%, respectively; P = .07), with a higher prevalence of CAD (61% vs 37%, P = ,0001) and CHF (18.2 vs 5.2%, P = .0003) in the CAS cohort.

Hospital Cost: The hospital cost for CAS ($9426 ± 5776) was 40% greater than that of CEA ($ 6734 ± 3935, P< .0001). This cost differential was driven by a mean difference of $3667 in higher direct supply costs in the CAS group ($5634 ± 3384) compared to the CEA group ($1967 ± 1967, P = .0001). There were no significant differences between CEA and CAS in regards to labor or facility costs (Fig 1). Subgroup analysis was performed comparing the cost of CEA and CAS for asymptomatic, symptomatic, elective, and urgent procedures (Fig 2). In all sub-group cohort comparisons, there was a consistent increase in cost for CAS compared to CEA. All of these differences were statistically significant (P< .001) except the urgent subgroup (P= .07). Cost of CAS and CEA was also examined in relation to patient enrollment in a trial or registry. Patients undergoing CAS who were enrolled in a trial or registry (53.8%, n = 71) incurred significantly less cost ($7779 ± 3525) compared to those who were not (n = 61, $11,279 ± 7114, P = .0004). There were no significant differences in cost for patients undergoing CEA regarding trial status.

Clinical Outcome: The 30-day major adverse event rate (stroke, death, MI) was 2.3% in the CEA group and 3.8% in the CAS group (P = .5).

Length of Stay: Overall LOS was 2.1 days in both CEA and CAS groups (P = .9). LOS in patients with symptomatic disease (2.9-3.6 days) or who had urgent intervention (7.3-7.5 days) was much greater than patients undergoing intervention electively or for asymptomatic disease (1.3-1.4 days). The LOS between CEA and CAS was similar in all these subgroups.

Conclusions: The hospital cost of CAS was demonstrated to be 40% greater than CEA. The cost differential in the present study was driven largely by the significant differential in direct supply costs in the CAS group of $3667. Current hospital costs for a carotid stent and embolic protection device is approximately $3750 - 4100 compared to $90-100 for a synthetic carotid patch used with endarterectomy. Clearly, the cost differential of these two therapies was due to the relatively high cost of the interventional products required for CAS. There was no net significant offsetting savings in facility or labors costs for the CAS patients as the length of stay was similar between the two treatment groups. This is the first carotid economic study to examine multiple treatment subgroups. Patients with urgent intervention incurred costs much greater in both groups than those who where treated electively. This cost differential was driven by the much greater LOS for urgent cases (7.3-7.5 days) compared with elective cases (1.3-1.4 days). Additional cost for diagnostic imaging in these cases also likely contributed. Patients being treated for symptomatic disease likewise had greater costs than those treated for asymptomatic disease. Increased LOS in the symptomatic groups (2.9-3.6 days) verses the asymptomatic group (1.3-1.4 days) certainly played a role. The relative cost trends between CAS and CEA seen in the primary cohorts were not altered in any subgroup. CAS was consistently more costly in each subgroup. A novel finding of this study was that CAS patients enrolled in a trial or registry had costs that were significantly less than those who were treated with CAS outside of a trial. These data refute the notion that the differential in cost between CEA and CAS is due, in part, to additional costs associated with protocol-mandated imaging and testing for patients enrolled in a trial or registry. The present study represents a "real world" cost analysis of CEA and CAS performed at a single, tertiary referral center with significant expertise and experience in both therapies. As such, it may provide a more realistic view of costs compared to data generated from clinical trials. While a small number of patients were part of randomized prospective trials (CREST, ACT-1), most treatment decisions were made by the intervening physician. Selection bias is a clear concern and could confound attempts to compare the treatment groups. In an attempt to decrease this possibility, we excluded patients who had other major procedures during the index hospitalization, or who were not admitted primarily because of TIA, stroke or carotid disease. Did the treatment groups have disparate demographics or clinical presentation? Patients undergoing CEA were more likely to have symptomatic disease when compared to those undergoing CAS. As symptomatic status is a very strong risk factor for peri-procedural stroke, this difference would suggest that the CEA group was at higher risk of a poor outcome, potentially biasing the results against CEA. Conversely, in the CAS group there was a higher prevalence of CAD and CHF, suggesting that group had a higher potential cardiac morbidity, potentially biasing the results against CAS. Patient age and other medical co-morbidities were similar between treatment groups. In conclusion, CAS was associated with a 40% cost premium when compared to CEA, and did not provide any improvement in clinical outcome or LOS. All subgroups had similar cost trends. Given the lack of clinical improvement and its cost premium, CAS cannot be considered routinely cost-effective for the treatment of carotid artery disease.

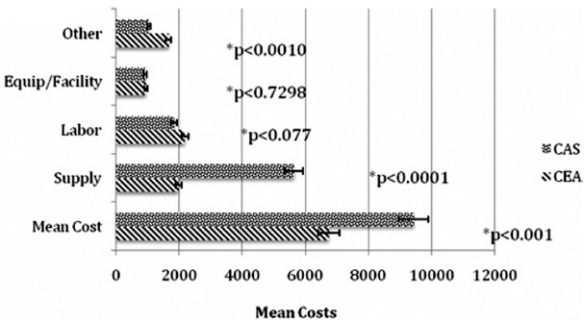

Fig 1.